

**Claims**

What is claimed is:

- Claim 1. A method of horizontally structured CAD/CAM automated manufacturing, comprising:  
selecting a blank for machining into an actual part;  
establishing a coordinate system;  
5 creating a master process model comprising:  
a virtual blank corresponding to said blank;  
a manufacturing feature;  
virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative relationship  
10 with said coordinate system; and  
generating machining instructions to create said actual part by machining said manufacturing feature into said blank;  
capturing manufacturing process rules in a spread sheet; and  
said spread sheet exhibiting another associative relationship with  
15 said master process model.

Claim 2. The method of Claim 1 wherein said associative relationship is a parent/child relationship.

Claim 3. The method of Claim 1 further including another manufacturing feature exhibiting an associative relationship with said manufacturing feature.

Claim 4. The method of Claim 3 wherein said associative relationship is a parent/child relationship.

Claim 5. The method of Claim 1 wherein said virtual blank exhibits an associative relationship with another said manufacturing feature.

Claim 6. The method of Claim 5 wherein said associative relationship is a parent/child relationship.

Claim 7. The method of Claim 1 wherein said virtual blank exhibits an associative relationship with said coordinate system.

Claim 8. The method of Claim 7 wherein said associative relationship is a parent/child relationship.

Claim 9. The method of Claim 1 further comprising creating extracts from said master process model.

Claim 10. The method of Claim 9 wherein said extracts comprise replicated models of said master process model at various operations of said manufacturing.

Claim 11. The method of Claim 9 wherein said extracts exhibit an associative relationship with said master process model.

Claim 12. The method of Claim 9 wherein said associative relationship is a parent/child relationship.

Claim 13. The method of Claim 9 wherein said extracts are used to generate manufacturing process sheets.

Claim 14. The method of Claim 1 wherein said virtual blank is positioned and oriented relative to said coordinate system.

Claim 15. The method of Claim 14 wherein said virtual blank is generated as a three dimensional parametric solid model from a reference set geometry.

Claim 16. The method of Claim 15 wherein said reference set geometry is defined by dimensional characteristics of a modeled part.

Claim 17. The method of Claim 1 wherein establishing said coordinate system comprises one or more datum planes.

Claim 18. The method of Claim 1 wherein said coordinate system comprises:

creating a first datum plane positioned and oriented relative to a reference;

5 creating a second datum plane positioned and oriented relative to said reference; and

creating a third datum plane positioned and oriented relative to said reference.

Claim 19. The method of Claim 18 wherein said first datum plane, said second datum plane, and said third datum plane are orthogonal.

Claim 20. The method of Claim 1 wherein said manufacturing instructions comprise process sheets.

Claim 21. The method of Claim 20 wherein said process sheets are linked with numerically controlled tools and a coordinate measuring machine.

Claim 22. The method of Claim 1 wherein said master process model is linked with numerically controlled tools and a coordinate measuring machine.

Claim 23. The method of Claim 1 wherein said another associative relationship is a parent/child relationship.

Claim 24. The method of Claim 3 wherein said virtual blank exhibits an associative relationship with another said manufacturing feature.

Claim 25. The method of Claim 24 wherein said associative relationship is a parent/child relationship.

Claim 26. The method of Claim 25 wherein said virtual blank exhibits an associative relationship with said coordinate system.

Claim 27. The method of Claim 26 wherein said associative relationship is a parent/child relationship.

Claim 28. The method of Claim 27 further comprising creating extracts from said master process model.

Claim 29. The method of Claim 28 wherein said extracts comprise replicated models of said master process model at various operations of said manufacturing.

Claim 30. The method of Claim 29 wherein said extracts exhibit an associative relationship with said master process model.

Claim 31. The method of Claim 30 wherein said associative relationship is a parent/child relationship.

Claim 32. The method of Claim 31 wherein said extracts are used to generate manufacturing process sheets.

Claim 33. The method of Claim 32 wherein said virtual blank is positioned and oriented relative to said coordinate system.

Claim 34. The method of Claim 33 wherein said virtual blank is generated as a three dimensional parametric solid model from a reference set geometry.

Claim 35. The method of Claim 34 wherein said reference set geometry is defined by dimensional characteristics of a modeled part.

Claim 36. The method of Claim 35 wherein establishing said coordinate system comprises one or more datum planes.

Claim 37. The method of Claim 36 wherein said coordinate system comprises:

creating a first datum plane positioned and oriented relative to a

reference;

5 creating a second datum plane positioned and oriented relative to  
said reference; and

creating a third datum plane positioned and oriented relative to  
said reference.

Claim 38. The method of Claim 37 wherein said first datum plane, said second datum plane, and said third datum plane are orthogonal.

Claim 39. The method of Claim 38 wherein said manufacturing instructions comprise process sheets.

Claim 40. The method of Claim 39 wherein said process sheets are linked with numerically controlled tools and a coordinate measuring machine.

Claim 41. The method of Claim 40 wherein said the master process model is linked with numerically controlled tools and a coordinate measuring machine.

Claim 42. The method of Claim 41 further including  
modifying a link among a plurality of modeling elements.

Claim 43. The method of Claim 42 wherein said link comprises an associative relationship.

Claim 44. The method of Claim 1 further including  
modifying a link among a plurality of modeling elements.

Claim 45. The method of Claim 44 wherein said link comprises an associative relationship.

Claim 46. The method of Claim 45 wherein said associative relationship is a parent/child relationship.

Claim 47. The method of Claim 44 wherein said modifying comprises removing said link among said modeling elements.

Claim 48. The method of Claim 44 wherein said modifying comprises establishing said link among said modeling elements.

Claim 49. The method of Claim 44 wherein said modifying links among modeling elements includes substituting a second plurality of modeling elements for said plurality of modeling elements.

Claim 50. The method of Claim 49 wherein said extracts are linked with numerically controlled tools and a coordinate measuring machine.

Claim 51. The method of Claim 50 wherein said extracts exhibit an associative relationship with said spread sheet.

Claim 52. The method of Claim 51 wherein said associative relationship is a parent/child relationship.

Claim 53. The method of Claim 52 wherein said process sheets exhibit an associative relationship with said spread sheet.

Claim 54. The method of Claim 53 wherein said associative relationship is a parent/child relationship.

Claim 55. The method of Claim 9 wherein said extracts are linked with numerically controlled tools and a coordinate measuring machine.

Claim 56. The method of Claim 55 wherein said extracts exhibit an associative relationship with said spread sheet.

Claim 57. The method of Claim 56 wherein said associative relationship is a parent/child relationship.

Claim 58. The method of Claim 13 wherein said process sheets exhibit an associative relationship with said spread sheet.

Claim 59. The method of Claim 58 wherein said associative relationship is a parent/child relationship.

Claim 60. A manufactured part created by a method of horizontally structured automated CAD/CAM manufacturing process, comprising:

a blank for machining into said manufactured part;

5 a coordinate system;

a master process model comprising:

a virtual blank corresponding to said blank;

a manufacturing feature wherein said manufacturing

feature is characterized by virtual machining of said manufacturing feature into 10 said virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system; and

said actual part created by machining said manufacturing feature into said blank in accordance with a machining instruction

manufacturing process rules captured in a spread sheet; and

15 said spread sheet exhibiting another associative relationship with said master process model.

Claim 61. The manufactured part of Claim 60 wherein said associative relationship is a parent/child relationship.

Claim 62. The manufactured part of Claim 60 further including another manufacturing feature exhibiting an associative relationship with said manufacturing feature.

Claim 63. The manufactured part of Claim 62 wherein said associative relationship is a parent/child relationship.

Claim 64. The manufactured part of Claim 60 wherein said virtual blank exhibits an associative relationship with another said manufacturing feature.

Claim 65. The manufactured part of Claim 64 wherein said associative relationship is a parent/child relationship.

Claim 66. The manufactured part of Claim 60 wherein said virtual blank exhibits an associative relationship with said coordinate system.

Claim 67. The manufactured part of Claim 66 wherein said associative relationship is a parent/child relationship.

Claim 68. The manufactured part of Claim 60 further comprising extracts created from said master process model.

Claim 69. The manufactured part of Claim 68 wherein said extracts comprise replicated models of said master process model at various operations of said manufacturing.

Claim 70. The manufactured part of Claim 68 wherein said extracts exhibit an associative relationship with said master process model.

Claim 71. The manufactured part of Claim 70 wherein said associative relationship is a parent/child relationship.

Claim 72. The manufactured part of Claim 68 wherein said extracts are used to generate manufacturing process sheets.

Claim 73. The manufactured part of Claim 60 wherein said virtual blank is positioned and oriented relative to said coordinate system.

Claim 74. The manufactured part of Claim 73 wherein said virtual blank is generated as a three dimensional parametric solid model from a reference set geometry.

Claim 75. The manufactured part of Claim 74 wherein said reference set geometry is defined by dimensional characteristics of a modeled part.

Claim 76. The manufactured part of Claim 60 wherein said coordinate system comprises one or more datum planes.

Claim 77. The manufactured part of Claim 60 wherein said coordinate system comprises:

a first datum plane positioned and oriented relative to a reference;

5 a second datum plane positioned and oriented relative to said reference; and

a third datum plane positioned and oriented relative to said reference.

Claim 78. The manufactured part of Claim 77 wherein said first datum plane, said second datum plane, and said third datum plane are orthogonal.

Claim 79. The manufactured part of Claim 60 wherein said manufacturing instructions comprise process sheets.

Claim 80. The manufactured part of Claim 79 wherein said process sheets are linked with numerically controlled tools and a coordinate measuring machine.

Claim 81. The manufactured part of Claim 60 wherein said master process model is linked with numerically controlled tools and a coordinate measuring machine.

Claim 82. The manufactured part of Claim 60 wherein said another associative relationship is a parent/child relationship.

Claim 83. The manufactured part of Claim 82 wherein said virtual blank exhibits an associative relationship with another said manufacturing feature.

Claim 84. The manufactured part of Claim 83 wherein said associative relationship is a parent/child relationship.

Claim 85. The manufactured part of Claim 84 wherein said virtual blank exhibits an associative relationship with said coordinate system.

Claim 86. The manufactured part of Claim 85 wherein said associative relationship is a parent/child relationship.

Claim 87. The manufactured part of Claim 86 further comprising extracts created from said master process model.

Claim 88. The manufactured part of Claim 87 wherein said extracts comprise replicated models of said master process model at various operations of said manufacturing.

Claim 89. The manufactured part of Claim 88 wherein said extracts exhibit an associative relationship with said master process model.

Claim 90. The manufactured part of Claim 89 wherein said associative relationship is a parent/child relationship.

Claim 91. The manufactured part of Claim 90 wherein said extracts are used to generate manufacturing process sheets.

Claim 92. The manufactured part of Claim 91 wherein said virtual blank is positioned and oriented relative to said coordinate system.

Claim 93. The manufactured part of Claim 92 wherein said virtual blank is generated as a three dimensional parametric solid model from a reference set geometry.

Claim 94. The manufactured part of Claim 93 wherein said reference set geometry is defined by dimensional characteristics of a modeled part.

Claim 95. The manufactured part of Claim 94 wherein said coordinate system comprises one or more datum planes.

Claim 96. The manufactured part of Claim 95 wherein said coordinate system comprises:

a first datum plane positioned and oriented relative to a reference;

5 a second datum plane positioned and oriented relative to said reference; and

a third datum plane positioned and oriented relative to said reference.

Claim 97. The manufactured part of Claim 96 wherein said first datum plane, said second datum plane, and said third datum plane are orthogonal.

Claim 98. The manufactured part of Claim 97 wherein said manufacturing instructions comprise process sheets.

Claim 99. The manufactured part of Claim 98 wherein said process sheets are linked with numerically controlled tools and a coordinate measuring machine.

Claim 100. The manufactured part of Claim 99 wherein said the master process model is linked with numerically controlled tools and a coordinate measuring machine.

Claim 101. The manufactured part of Claim 100 further includes a modifiable link among a plurality of modeling elements.

Claim 102. The manufactured part of Claim 101 wherein said link comprises an associative relationship.

Claim 103. The manufactured part of Claim 102 wherein said the extracts are linked with numerically controlled tools and a coordinate measuring machine.

Claim 104. The manufactured part of Claim 103 wherein said extracts exhibit an associative relationship with said spread sheet.

Claim 105. The manufactured part of Claim 104 wherein said associative relationship is a parent/child relationship.

Claim 106. The manufactured part of Claim 105 wherein said manufacturing process sheets exhibit an associative relationship with said spread sheet.

Claim 107. The manufactured part of Claim 106 wherein said associative relationship is a parent/child relationship.

Claim 108. The manufactured part of Claim 60 further includes a modifiable link among a plurality of modeling elements.

Claim 109. The manufactured part of Claim 108 wherein said link comprises an associative relationship.

Claim 110. The manufactured part of Claim 109 wherein said associative relationship is a parent/child relationship.

Claim 111. The manufactured part of Claim 108 wherein said modifiable link is removed from among said modeling elements.

Claim 112. The manufactured part of Claim 108 wherein said modifiable link is established among said modeling elements.

Claim 113. The manufactured part of Claim 108 wherein said modifiable link among modeling elements includes a substituted second plurality of modeling elements for said plurality of modeling elements.

Claim 114. The manufactured part of Claim 68 wherein said the extracts are linked with numerically controlled tools and a coordinate measuring machine.

Claim 115. The manufactured part of Claim 114 wherein said extracts exhibit an associative relationship with said spread sheet.

Claim 116. The manufactured part of Claim 115 wherein said associative relationship is a parent/child relationship.

Claim 117. The manufactured part of Claim 80 wherein said process sheets exhibit an associative relationship with said spread sheet.

Claim 118. The manufactured part of Claim 117 wherein said associative relationship is a parent/child relationship.

Claim 119. A storage medium encoded with a machine-readable computer program code for horizontally structured automated CAD/CAM manufacturing, said storage medium including instructions for causing a computer to implement a method comprising:

- 5                   selecting a blank for machining into an actual part;
- establishing a coordinate system;
- creating a master process model comprising:
  - a virtual blank corresponding to said blank;
  - a manufacturing feature;
  - virtual machining of said manufacturing feature into said virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system; and
  - generating machining instructions to create said actual part by machining said manufacturing feature into said blank;
- 10                  capturing manufacturing process rules in a spread sheet; and
- said spread sheet exhibiting another associative relationship with said master process model.

Claim 120. The storage medium of Claim 119 wherein said associative relationship is a parent/child relationship.

Claim 121. The storage medium of Claim 119 further including another manufacturing feature exhibiting an associative relationship with said manufacturing feature.

Claim 122. The storage medium of Claim 121 wherein said associative relationship is a parent/child relationship.

Claim 123. The storage medium of Claim 119 wherein said virtual blank exhibits an associative relationship with another said manufacturing feature.

Claim 124. The storage medium of Claim 123 wherein said associative relationship is a parent/child relationship.

Claim 125. The storage medium of Claim 119 wherein said virtual blank exhibits an associative relationship with said coordinate system.

Claim 126. The storage medium of Claim 125 wherein said associative relationship is a parent/child relationship.

Claim 127. The storage medium of Claim 119 further comprising creating extracts from said master process model.

Claim 128. The storage medium of Claim 127 wherein said extracts comprise replicated models of said master process model at various operations of said manufacturing.

Claim 129. The storage medium of Claim 127 wherein said extracts exhibit an associative relationship with said master process model.

Claim 130. The storage medium of Claim 127 wherein said associative relationship is a parent/child relationship.

Claim 131. The storage medium of Claim 127 wherein said extracts are used to generate manufacturing process sheets.

Claim 132. The storage medium of Claim 119 wherein said virtual blank is positioned and oriented relative to said coordinate system.

Claim 133. The storage medium of Claim 132 wherein said virtual blank is generated as a three dimensional parametric solid model from a reference set geometry.

Claim 134. The storage medium of Claim 133 wherein said reference set geometry is defined by dimensional characteristics of a modeled part.

Claim 135. The storage medium of Claim 119 wherein establishing said coordinate system comprises one or more datum planes.

Claim 136. The storage medium of Claim 119 wherein said coordinate system comprises:

creating a first datum plane positioned and oriented relative to a reference;

5 creating a second datum plane positioned and oriented relative to said reference; and

creating a third datum plane positioned and oriented relative to said reference.

Claim 137. The storage medium of Claim 136 wherein said first datum plane, said second datum plane, and said third datum plane are orthogonal.

Claim 138. The storage medium of Claim 119 wherein said manufacturing instructions comprise process sheets.

Claim 139. The storage medium of Claim 138 wherein said process sheets are linked with numerically controlled tools and a coordinate measuring machine.

Claim 140. The storage medium of Claim 119 wherein said master process model is linked with numerically controlled tools and a coordinate measuring machine.

Claim 141. The storage medium of Claim 119 wherein said another associative relationship is a parent/child relationship.

Claim 142. The storage medium of Claim 119 further including modifying a link among a plurality of modeling elements.

Claim 143. The storage medium of Claim 142 wherein said link comprises an associative relationship.

Claim 144. The storage medium of Claim 143 wherein said associative relationship is a parent/child relationship.

Claim 145. The storage medium of Claim 142 wherein said modifying comprises removing said link among said modeling elements.

Claim 146. The storage medium of Claim 142 wherein said modifying comprises establishing said link among said modeling elements.

Claim 147. The storage medium of Claim 142 wherein said modifying links among modeling elements includes substituting a second plurality of modeling elements for said plurality of modeling elements.

Claim 148. The storage medium of Claim 127 wherein said the extracts are linked with numerically controlled tools and a coordinate measuring machine.

Claim 149. The storage medium of Claim 127 wherein said extracts exhibit an associative relationship with said spread sheet.

Claim 150. The storage medium of Claim 149 wherein said associative relationship is a parent/child relationship.

Claim 151. The storage medium of Claim 138 wherein said process sheets exhibit an associative relationship with said spread sheet.

Claim 152. The storage medium of Claim 151 wherein said associative relationship is a parent/child relationship.

- Claim 153. A computer data signal for horizontally structured automated CAD/CAM manufacturing, said computer data signal comprising code configured to cause a processor to implement a method comprising:
- 5           selecting a blank for machining into an actual part;
- establishing a coordinate system;
- creating a master process model comprising:
- a virtual blank corresponding to said blank;
- a manufacturing feature;
- virtual machining of said manufacturing feature into said
- 10        virtual blank, said manufacturing feature exhibiting an associative relationship with said coordinate system; and
- generating machining instructions to create said actual part by machining said manufacturing feature into said blank;
- capturing manufacturing process rules in a spread sheet; and
- 15        said spread sheet exhibiting another associative relationship with said master process model.

Claim 154. The computer data signal of Claim 153 wherein said associative relationship is a parent/child relationship.

Claim 155. The computer data signal of Claim 153 further including another manufacturing feature exhibiting an associative relationship with said manufacturing feature.

Claim 156. The computer data signal of Claim 155 wherein said associative relationship is a parent/child relationship.

Claim 157. The computer data signal of Claim 153 wherein said virtual blank exhibits an associative relationship with another said manufacturing feature.

Claim 158. The computer data signal of Claim 157 wherein said associative relationship is a parent/child relationship.

Claim 159. The computer data signal of Claim 153 wherein said virtual blank exhibits an associative relationship with said coordinate system.

Claim 160. The computer data signal of Claim 159 wherein said associative relationship is a parent/child relationship.

Claim 161. The computer data signal of Claim 153 further comprising creating extracts from said master process model.

Claim 162. The computer data signal of Claim 161 wherein said extracts comprise replicated models of said master process model at various operations of said manufacturing.

Claim 163. The computer data signal of Claim 161 wherein said extracts exhibit an associative relationship with said master process model.

Claim 164. The computer data signal of Claim 161 wherein said associative relationship is a parent/child relationship.

Claim 165. The computer data signal of Claim 161 wherein said extracts are used to generate manufacturing process sheets.

Claim 166. The computer data signal of Claim 153 wherein said virtual blank is positioned and oriented relative to said coordinate system.

Claim 167. The computer data signal of Claim 166 wherein said virtual blank is generated as a three dimensional parametric solid model from a reference set geometry.

Claim 168. The computer data signal of Claim 167 wherein said reference set geometry is defined by dimensional characteristics of a modeled part.

Claim 169. The computer data signal of Claim 153 wherein establishing said coordinate system comprises one or more datum planes.

Claim 170. The computer data signal of Claim 153 wherein said coordinate system comprises:

creating a first datum plane positioned and oriented relative to a reference;

5 creating a second datum plane positioned and oriented relative to said reference; and

creating a third datum plane positioned and oriented relative to said reference.

Claim 171. The computer data signal of Claim 170 wherein said first datum plane, said second datum plane, and said third datum plane are orthogonal.

Claim 172. The computer data signal of Claim 153 wherein said manufacturing instructions comprise process sheets.

Claim 173. The computer data signal of Claim 172 wherein said process sheets are linked with numerically controlled tools and a coordinate measuring machine.

Claim 174. The computer data signal of Claim 153 wherein said master process model is linked with numerically controlled tools and a coordinate measuring machine.

Claim 175. The computer data signal of Claim 153 wherein said associative relationship is a parent/child relationship.

Claim 176. The computer data signal of Claim 153 further comprising code configured to cause a processor to implement a method further including modifying a link among a plurality of modeling elements.

Claim 177. The computer data signal of Claim 176 wherein said link comprises an associative relationship.

Claim 178. The computer data signal of Claim 177 wherein said associative relationship is a parent/child relationship.

Claim 179. The computer data signal of Claim 176 wherein said modifying comprises removing said link among said modeling elements.

Claim 180. The computer data signal of Claim 176 wherein said modifying comprises establishing said link among said modeling elements.

Claim 181. The computer data signal of Claim 176 wherein said modifying links among modeling elements includes substituting a second plurality of modeling elements for said plurality of modeling elements.

Claim 182. The computer data signal of Claim 153 wherein said another associative relationship is a parent/child relationship.

Claim 183. The computer data signal of Claim 161 wherein said the extracts are linked with numerically controlled tools and a coordinate measuring machine.

Claim 184. The computer data signal of Claim 161 wherein said extracts exhibit an associative relationship with said spread sheet.

Claim 185. The computer data signal of Claim 184 wherein said associative relationship is a parent/child relationship.

Claim 186. The computer data signal of Claim 172 wherein said process sheets exhibit an associative relationship with said spread sheet.

Claim 187. The computer data signal of Claim 186 wherein said associative relationship is a parent/child relationship.